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Competitive interactions between the earthworm *Dendrobaena octaedra* and the enchytraeid *Cognettia sphagnetorum*

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Summary. In boreal coniferous forest soil, the earthworm *Dendrobaena octaedra* and the enchytraeid *Cognettia sphagnetorum* are the two most dominating invertebrate species in terms of biomass. In dry pine forest soil with low pH, *Dendrobaena* is absent, while both occur together in more fertile spruce forests with slightly higher soil pH. As both species are considered detritus feeders, competitive interactions between them are expected in the case of co-occurrence. To examine this, microcosms were set up containing: (1) initially 5 specimens of *Dendrobaena* per jar, (2) initially 105 specimens of *Cognettia* per jar, and (3) both together. They were kept at 16 °C, and examined at 8, 18 and 28 weeks. The presence of *Dendrobaena* suppressed the population of *Cognettia* by roughly 50 % at both moistures. *Dendrobaena* biomass was less, though not significantly so, in the presence of *Cognettia* than in its absence. The presence of *Dendrobaena* also decreased considerably the numbers of nematodes.

Key words: *Dendrobaena octaedra*, *Cognettia sphagnetorum*, Nematoda, forest soil, competition, interactions

Introduction

In boreal coniferous forests of medium productivity (spruce stands of *Myrtillus* type), *Dendrobaena octaedra* (Lumbricidae) and *Cognettia sphagnetorum* (Enchytraeidae) are the most important soil animal species in terms of biomass (Huhta & Koskenniemi 1975). In related forests at more northern latitudes (*Hylocomium-Myrtillus* type spruce stands), and in dry, less productive pine stands (*Calluna*-type) *D. octaedra* is sparse or lacking, leaving *C. sphagnetorum* the dominating faunal component (Nurminen 1967a,b; Huhta & Koskenniemi 1975; Persson et al. 1980; Huhta et al. 1986). Both species have been regarded as detritus feeders (Springett & Latter 1977; Latter & Howson 1978; McLean et al. 1996), though *C. sphagnetorum* is also known to feed on fungal hyphae (Springett & Latter 1977; Hedlund & Augustsson 1995), and *D. octaedra* may also derive its nutrition from living biomass (Hyvönen et al. 1994). Because the two species potentially consume the same resources, competitive relationships are likely to occur between them in the case of coexistence. Haukka (1987) has demonstrated related interactions and their dependence on physical conditions between the earthworm *Eisenia andrei* and the enchytraeid *Enchytraeus albidus*, living together in composts.

This experiment was planned to test the hypothesis that *Dendrobaena octaedra* and *Cognettia sphagnetorum* affect each other's populations when living together. The effects of

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both species on nematode populations and N mineralisation were also monitored. The experiment was carried out using spruce forest soil of good productivity, expected to support both earthworms and enchytraeids.

Material and Methods

Organic topsoil (pH 5.5, water content 51 % of fresh mass, loss on ignition 34 %) was taken from a mixed forest of *Oxalis-Myrtillus*-type, dominated by Norway spruce, 10 km W of Jyväskylä, central Finland. The soil was sieved (∅ 10 mm) to separate coarse material and mosses, defaunated by keeping overnight at 65 °C, and dried at 35–40 °C for 3 days until the water content was 34 %. It was then separated into two portions, which were rewetted to 51.2 and 56.5 % of fresh mass, later referred to as 'moist' and 'wet' treatments.

102 g (d.m.) portions of soil were weighed into plastic jars (∅ 14 cm, height 15 cm), closed by lids with a 7 mm aperture and cotton wool plug to allow gas exchange. Earthworms (*Dendrobaena octaedra* Sav.) and enchytraeids (*Cognettia sphagnetorum* Vejd.) were extracted from spruce forest humus, and introduced into three faunal treatments (n = 5) at both moisture contents as follows:

(1) earthworms alone, 5 specimens per jar (adult or subadult, average fresh weight 18.6 mg),

(2) enchytraeids alone, 105 specimens per jar, and

(3) both together.

The microcosms were incubated at 16 °C, water being added at times to compensate for evaporation. Sampling was carried out at weeks 8, 18 and 28 as follows: the jar contents were spread on white plastic in good illumination, and the earthworms were collected and weighed. Subsamples of 5 g (d.m.) were taken for extracting enchytraeids, 1 g for nematodes (wet funnel extraction), and 1 g for determining the contents of NH_4-N (2 M KCl-extraction; SFS standard 3032). The rest of the soil and the earthworms were returned to the jars. The biomasses of enchytraeids were determined as by Huhta et al. (1986).

The data were analysed using ANOVA, and the Student-Neuman-Keuls test for paired comparisons. Normality of distribution was checked using the Kolgomorov-Smirnov test, and homogeneity of variances using the Barlett-Box test. Logarithmic transformation was applied before testing enchytraeid biomasses and nematode numbers.

Results and Discussion

The presence of *Dendrobaena* decreased both numbers and biomass of *Cognettia* (ANOVA: $F = 80.2$, $p < 0.001$). The effect was not yet evident at week 8, but later on the enchytraeid biomass was twice or more higher without earthworms (Fig. 1A). Górny (1984) also observed a negative effect of the earthworms *Aporrectodea caliginosa* and *Lumbricus terrestris* on populations of enchytraeids (several species) in a calcareous soil in Poland. Hyvönen et al. (1994) showed that *D. octaedra* reduced the biomass of *C. sphagnetorum* in limed soil (pH 5.5), but not in an unlimed one (pH 4.5).

The influence of *Cognettia* on *Dendrobaena* was not significant, but there was a tendency for an increased earthworm biomass in the absence of enchytraeids (Fig. 1B). Both populations decreased by the last sampling (week 28) in the "wet" treatment.

There was hardly any difference between the numbers in the "moist" and "wet" treatment in this experiment. Obviously the populations did not suffer from water deficiency in "moist" soil, nor from excess water in "wet". Abrahamsen (1971) has shown that population growth of *C. sphagnetorum* is correlated with soil moisture at pF values between 3 and 4, and even a very high water content (100 % WHC) does not harm the species.

Nematodes invaded the microcosms evidently with the worm inoculations, and reproduced vigorously. However, in the presence of *Dendrobaena* alone their numbers remained very low (Fig. 1C). The highest nematode density was observed with *Cognettia* alone in "moist" soil at the last sampling (ANOVA, treatment effect: $F = 5.61$, $p = 0.01$; treatment x time; $F = 12.99$, $p < 0.001$).

The observed relationship between *D. octaedra* and *C. sphagnetorum* indicates competition for common resources. However, nutrition biology of both species is still incompletely known. *D. octaedra* is generally regarded as a detritus feeder, and McLean et al. (1996) have successfully grown it in pine forest floor materials. *C. sphagnetorum* is a primary decompo-

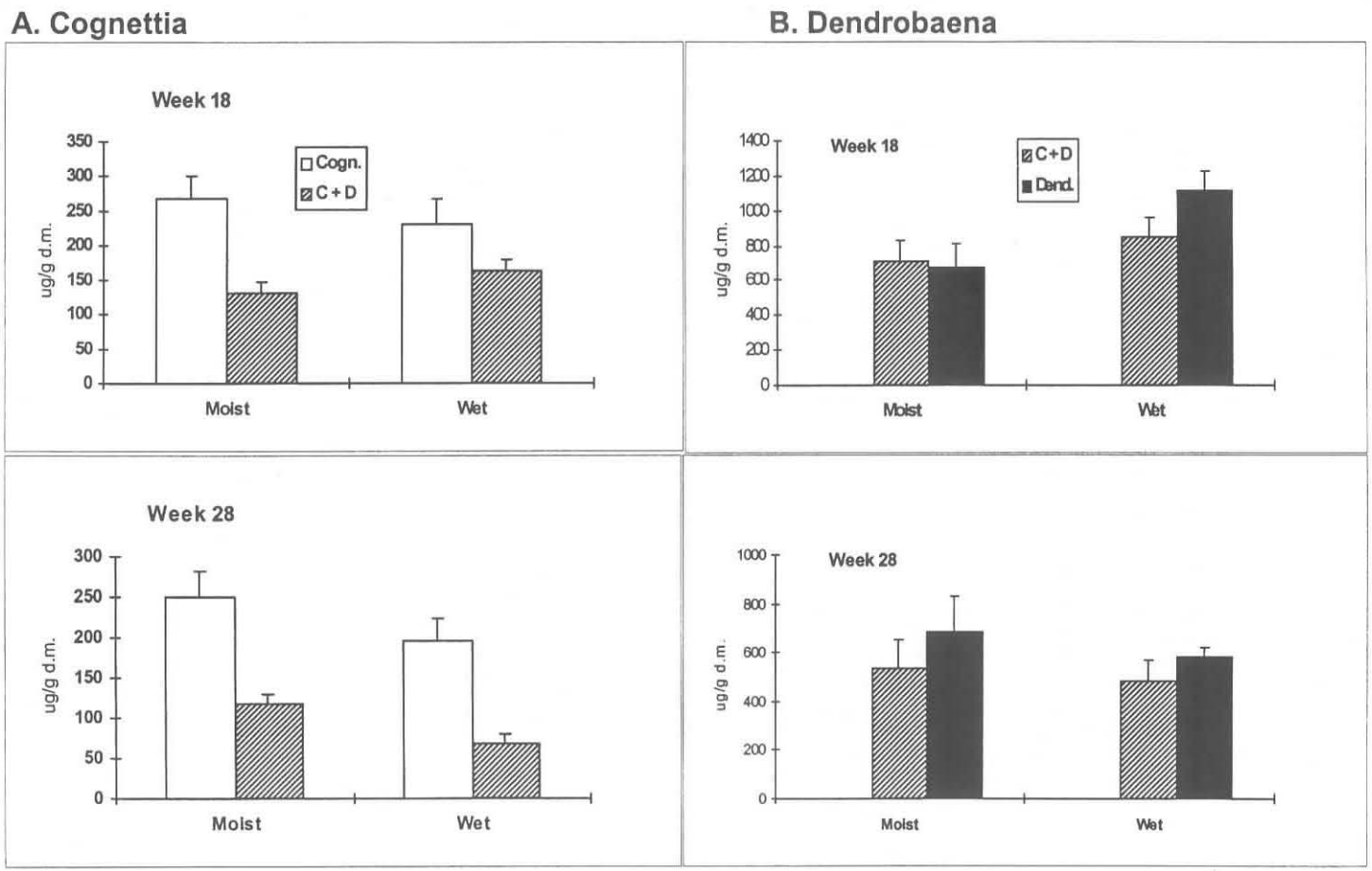
A. Cognettia
B. Dendrobaena
Week 18
Week 28
Cogn.
C+D
Dend.
ug/g d.m.
Moist
Wet
0
50
100
150
200
250
300
350
400
600
800
1000
1200
1400

Fig. 1A, B

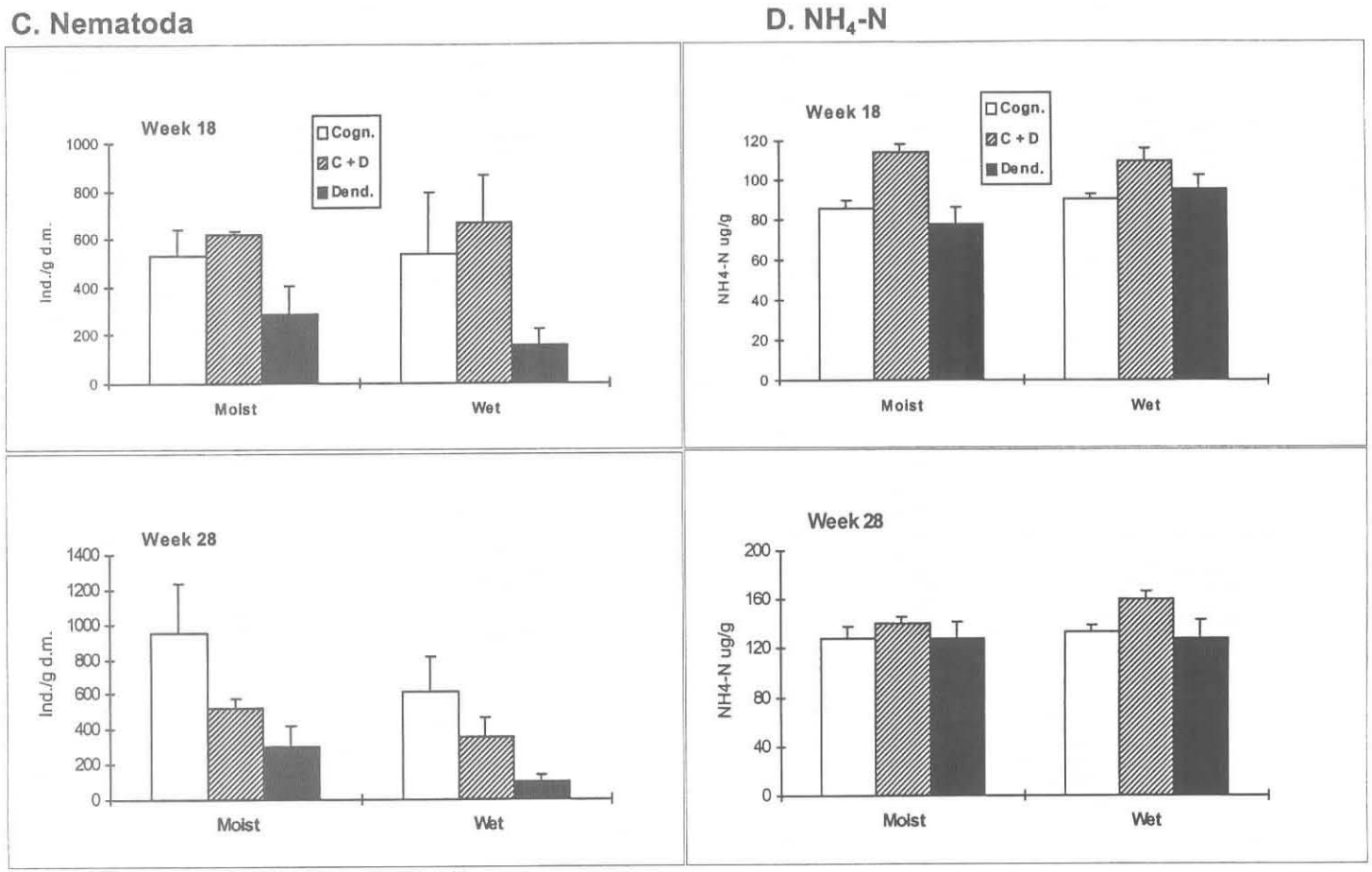

Fig. 1. Biomasses of *Cognettia sphagnetorum* (A) and *Dendrobaena octaedra* (B), numbers of nematodes (C) and concentration of ammonium nitrogen (D) in the 'moist' and 'wet' treatments at weeks 18 and 28. 'Cogn.'= *Cognettia* alone, 'Dend.'= *Dendrobaena* alone, 'C + D' = both together

ser according Latter & Howson (1978), but it also grows well in fungal cultures (Hedlund & Augustsson 1995). As in this experiment, Hyvönen et al. (1994) observed a negative effect of *Dendrobaena* on nematodes in limed soil (pH 5.5), and considered that the earthworms consume nematodes as food. Enchytraeids, on the other hand, have not been shown to affect nematodes (Hyvönen et al. 1994; Sulkava et al. 1996; Huhta et al. 1998). Obviously, although both species derive their nutrition from decomposing litter, their resource utilisation only partly overlaps; thus they can coexist although affecting each others' populations.

Net mineralisation of nitrogen (NH_4^+; the amount of NO_3^- in this soil is negligible) was highest when both *Dendrobaena* and *Cognettia* were present (Fig. 1D) (ANOVA: $F = 11.82$, $p < 0.001$). It was not correlated with animal biomasses as in some earlier experiments (Sulkava et al. 1996); NH_4^+-concentration was similar in both single-species cultures despite the fact that the total biomass was low in the culture with *Cognettia* alone. The total oligochaete biomass was similar in the presence of *Dendrobaena* alone, and both species together, except in the "moist" treatment at week 18. (On the other hand, it should be noted that as a smaller organism the enchytraeid may have a substantially greater turnover rate.)

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